Volume 095
Article 07

FISHERY RESEARCH

Job Performance Report

WILD TROUT EVALUATIONS

Job 2. Seasonal Movement and Spawning Mortality of Fluvial Bull Trout in Rapid River, Idaho

by

Dan Schill
Principal Fisheries Research Biologist, IDFG

Russ Thurow
Research Scientist, USFS

Paul Kline
Senior Fisheries Technician, IDFG

IDFG 94-13
May 1994

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (cont.)

LIST OF APPENDICES

JOB PERFORMANCE REPORT

State of: Idaho

Name: Wild Trout Evaluations

Project: F-73-R-15

Title: Seasonal Movement and Spawning Mortality of Fluvial Bull Trout in Rapid River, Idaho.

Subproject: II

Job: 2

Study: IV

Period Covered: April 1, 1992 to March 31, 1993

ABSTRACT

Knowledge of population dispersal is important in managing bull trout *Salvelinus confluentus* stocks. Actions protecting or enhancing the species may perform poorly if movement patterns are not clearly understood. Identification of spawning locations is critical to land-management decisions. We studied the spawning run and subsequent winter movement and habitat use of bull trout ascending Rapid River, a tributary to the Little Salmon River. We implanted radio-tags in 30 bull trout from May 28 to June 1, 1992 and used both ground tracking on foot and aerial surveys to monitor movements through March 1993. The greatest distance moved by an individual bull trout during the 10 month period was 100 km. The average bull trout moved 22 km upstream from their release point during the spawning run (range = 4.8-29.3 km). We observed a pulse of downstream movement in mid-summer. The likelihood of this behavior occurring was related to fish size. Over half of the fish less than 457 mm in length did not appear in documented spawning areas. Data suggest that a portion of the run may not ascend the stream to spawn. Spawning activity was limited to four principal reaches in the uppermost 10 km in the drainage. Post-spawning mortality of radio-tagged fish was 67%. If confirmed with additional data, this high rate will have major implications in setting appropriate regulations for enhancement of the species. Overwintering bull trout showed strong site fidelity after entering the main Salmon River. Individuals typically remained within a single habitat unit during the entire 6-month monitoring period. Our results suggest that the Rapid River stock overwinters within a popular steelhead trout *Oncorhynchus mykiss* fishery and may be subjected to incidental exploitation.

Authors:

Dan Schill
Principal Fisheries Research Biologist
Idaho Department of Fish and Game

Russ Thurow Research
Scientist
USFS Intermountain Research Station

Paul Kline
Senior Fisheries Technician
Idaho Department Fish and Game

INTRODUCTION

The bull trout Salvelinus confluentus is the least understood salmonid residing in Idaho waters. The ability of this species to grow to large sizes in unproductive systems provides a unique fisheries opportunity. Concern regarding the status of the species has prompted interest in bull trout life history and habitat requirements.

Biologists find bull trout a difficult fish to study because of their low densities and cryptic behavior. In Idaho, bull trout are typically present in low numbers (<0.10 fish/100 m^2). Over 75% of snorkeling sites scattered over a broad geographic area within the species range in Idaho did not contain any bull trout (Schill 1992). Low densities may represent accurate counts or may be negatively biased due to the cryptic nature of bull trout. Several authors have suggested that standard daytime snorkel methods are sometimes insufficient to enumerate bull trout (Goetz 1989; Shepard et al. 1982).

Extensive mobility also complicates life history study of the species. Adfluvial fish often move in excess of 75 km annually during spawning migrations (Fraley et al. 1981; Shepard et al. 1982). In the only study addressing fluvial bull trout movements in Idaho, Bjornn and Mallet (1964) documented extensive movement of adults in the Middle Fork Salmon River. The mean distance between tagging and recovery sites for fish exhibiting movement was 38 km (range = 1.7-325 km). This range of movement was only for lower portions of the river during periods of overwintering and early spring movement. The spawning migration was not studied but would have extended the above ranges greatly.

Because of this extensive mobility, knowledge of movement patterns is important to management of bull trout stocks. Understanding population dispersal in the main Salmon River will aid in the estimation of both natural and angling mortality for individual tributary stocks and will be used for development of regulations and their boundaries. Movement data will also be useful in identifying critical habitats to aid land management agencies in land-use decisions.

We studied the bull trout spawning run in Rapid River, a central Idaho tributary of the Little Salmon River. A permanent fish trap allowed capture of bull trout near the start of their upstream spawning migrations. We selected radio telemetry methods to monitor movements because of the remoteness of the drainage and recent success of the method in identifying bull trout spawning areas and general movement patterns (Mike Faler, US Forest Service, unpublished data).

OBJECTIVES

1. To document timing and location of spawning activity for fluvial bull trout in Rapid River.

2. To assess bull trout spawning mortality.

3. To document movement of the Rapid River population in the main Salmon River during late-fall/winter.

DESCRIPTION OF STUDY AREA

Rapid River is a fourth order stream flowing 30 km east to the Little Salmon River near Riggins in west-central Idaho (Figure 1). The stream drains a remote roadless area totaling approximately 31,000 hectares and is designated a wild and scenic corridor.

Rapid River is a narrow stream (mean width = 8 m) comprised largely of high gradient riffles, cascades and other fast water types. Overton et al. (1993) estimate the stream is comprised of 88.5% B channel and 11.5% A channel using the Rosgen (1985) methodology. Little C-type channel occurs in Rapid River. The substrate is primarily large cobble-rubble substrate. The flow regime is typical of many central Idaho streams. Peak runoff typically occurs in late-spring (May-June) with flows decreasing steadily to winter base flows. Average monthly flows in 1990 ranged from 1.7-7.1 m^3/s (US Forest Service, unpublished data).

Salmonids present in the drainage include steelhead trout _Oncorhynchus mykiss_, chinook salmon _Oncorhynchus tshawytscha_, brook trout _Salvelinus fontinalis_, and bull trout. Chinook salmon are found predominately in the lower third of the drainage based on snorkel observations (Kerry Overton (US Forest Service), unpublished data). Brook trout are present in upper reaches of the Lake Fork, a headwater tributary and possibly in others as a result of past high mountain lake plants.

Rapid River contains a sizable spawning run of bull trout that has ranged from 91-461 fish in the last 20 years (Schill 1992). Counts are based on records from the Rapid River chinook hatchery located about 1.7 km above the mouth of the stream. A velocity barrier and trap permits handling of all upstream bull trout migrants during the spring/summer period of salmon and steelhead trout trapping. In typical years, the bull trout spawning run begins in Mid-April, peaks in early June and is largely complete by the end of July (Schill 1992).

METHODS

Surgery

All bull trout ascending the stream from April 30 to August 31 were measured for total length by Rapid River Fish Hatchery personnel and released upstream of the hatchery intake dam. We implanted radio tags in a subsample of the run (30 bull trout) on May 27-30 and June 1.

Study fish were held in hardware-cloth pens in raceways prior to surgery. We anesthetized fish in a large stock tank with MS222 and measured lengths and weights to the nearest millimeter and 10 g, respectively. Fish were placed in

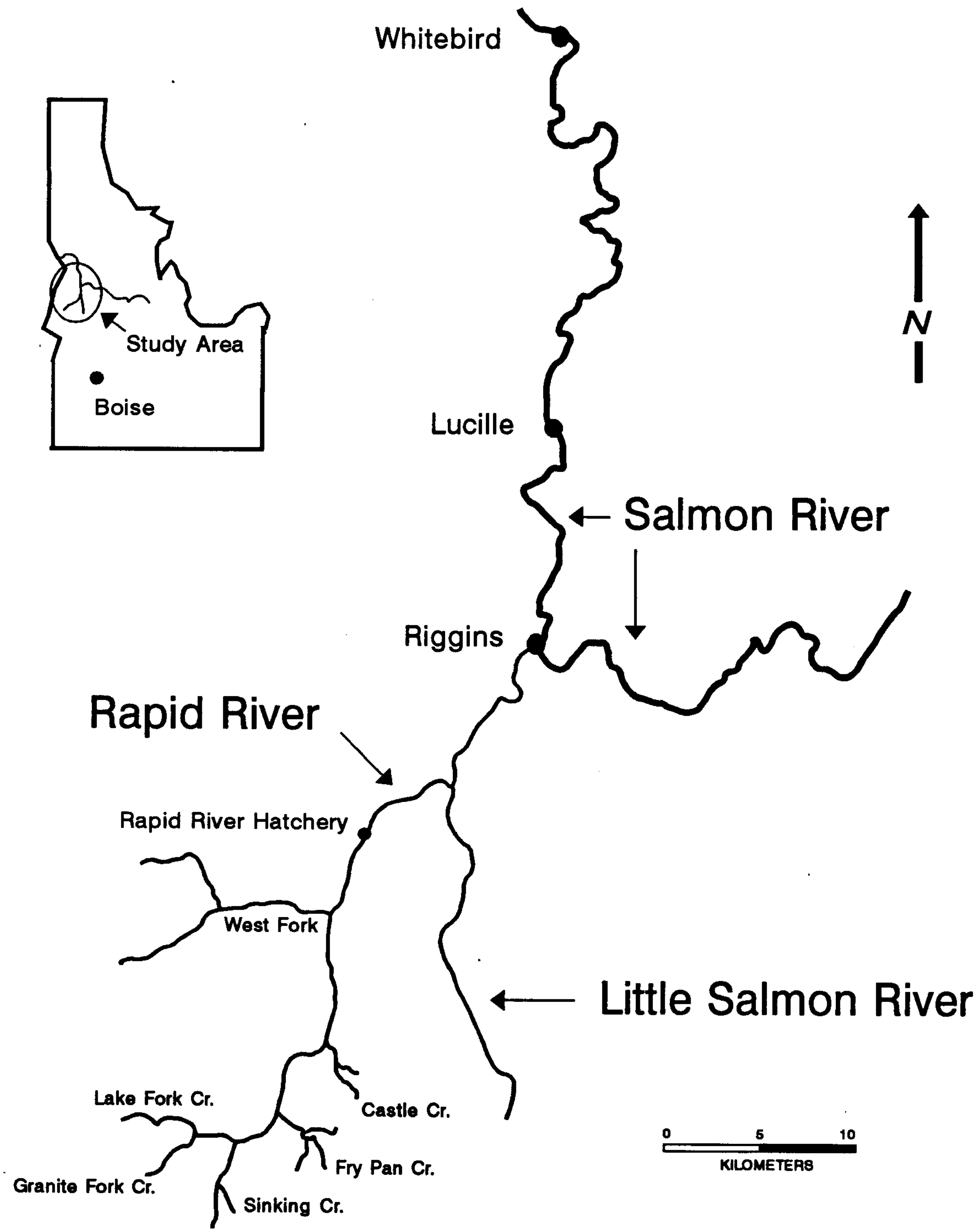

Figure 1. Study site for the Rapid River radio telemetry study.

a net cradle and gills were aerated using a garden sprayer and a bilge pump that recirculated water from the. stock tank. To avoid heat stress and anglers observing releases, we conducted surgery between the hours of 2100 and 1500.

Surgical procedures were similar to those of Rich (1992). A 20-30 mm incision was made through the ventral abdominal wall just anterior to the pelvic girdle. The external whip antennae was placed just posterior the pelvic girdle using a modification of the shielded needle technique (Ross and Kleiner 1982; Rich 1992). After inserting the transmitter in the coelomic cavity we closed the incision with three to four stitches using a 1/2 curved needle and 4-0 collagen suture. Betadyne was applied to the incision location before and after the surgery as well as at the antennae exit site. We also floy-tagged fish (Dell 1968) to facilitate visual identification of radio-tagged trout on the spawning beds and to monitor radio-tag expulsion. Individual fish were held in a recovery tank 10-40 min before release back into the stream above the hatchery intake.

The receiver and three sizes of tags (6, 10, and 20 g) were purchased from Advanced Telemetry Systems Inc. (ATS), Insanti Minnesota. Unique individual frequencies ranged from 150.015 to 150.595 Mhz. The tags were 35, 45, and 55 mm long and varied in diameter from 12-20 mm. Marty and Summerfelt (1986) suggest limiting transmitter weights to less than 2% of the fish's weight to reduce the incidence of tag expulsion. We followed these guidelines and used appropriate tags for individual fish.

We used two types of tags including standard transmitters (25 tags) and experimental temperature sensors (five tags). Temperatures were estimated in the latter by counting the number of pulses heard in three, 11 s intervals, averaging the results and using regressions developed for each individual tag by the manufacturer. We verified the accuracy of the temperature tag estimates by measuring the focal point temperatures on visual bull trout sightings to within 0.2°C on eight occasions. Results were tested with correlation analysis.

Radio-tracking

Rapid River

We used both aerial and ground tracking on foot to monitor bull trout movements in Rapid River. Ground tracking was used throughout the year but most heavily in early June when fish were within 10 km of the hatchery and in August during spawning. We used an ATS model R2100 receiver equipped with a three element yagi directional antennae to locate fish. We used the point of maximum acoustic signal strength to approximate fish locations and used a visual signal strength display at lower power gain to pinpoint actual fish locations. We measured air and water temperatures at all locations.

We sought visual contacts with fish when possible to ensure that fish were alive. Either the visual observation or maximum visual signal strength was considered the location for individual fish. It was sometimes difficult to know when a fish was dead. If we probed a hidden fish's location, and it did not move, and if no subsequent tag movement occurred, we assumed it had died by the second observation date.

A variety of habitat parameters were subsequently measured at each observation site. These data and a drainage-wide habitat inventory are being used in an ongoing habitat selection study for spawning bull trout. Results will be reported in a future.US Forest Service report.

Upon commencement of spawning we noted redd locations and measured a variety of physical redd attributes that will be summarized in the above companion report. We were unable to associate redds with radio-tagged fish in two portions of the drainage during the height of spawning activity. We conducted in-stream redd counts in a 2 km length of stream at both sites to verify the presence/absence of spawning activity.

Aerial tracking was used to aid in ground survey logistics and to locate fish missing from ground surveys. Tracking was conducted approximately 330 m above the stream at 136-153 kmh with a single antennae mounted on a wing strut. We scanned transmitter frequencies at 2 s intervals using a programmable receiver. The point of maximum acoustic signal strength was considered the location of a tagged fish.

The dates of all ground and aerial radio-tracking efforts are listed in Appendix A. We marked all telemetry locations on US Geological Survey topographic maps. Upon completion of the field season, we digitized the drainage, entered all observation locations and estimated distances traveled directly using an Altek Datatab. We used a one-tailed Fishers Exact Test (Zar 1974) to examine different movement patterns of two size classes of tagged bull trout.

Main Salmon River

Tracking efforts for fish in the Salmon River were similar except that ground surveys were done by vehicle. A total of eight ground surveys were completed between September 18, 1993 and March 22, 1994. We categorized the type of habitat utilized by fish at all locations after Sisson et al. (1982). Habitat types included pools, runs, glides and riffles. We photographed our estimated fish locations with a polaroid camera and marked locations on topo maps. Photos were used to aid in determining future movement within an individual habitat unit. Aerial surveys were conducted on three occasions to locate fish missing from the ground surveys.

RESULTS

Rapid River

A total of 271 bull trout were trapped during the 1992 spawning migration. The run began on April 30, peaked during the last week of May and was largely complete by July 7 (Figure 2). The last upstream migrant was captured on August 31. Fish ranged in total length from 200-620 mm and averaged 407 mm (Figure 3). We were unable to visually sex the fish at this time.

Because of tag:fish weight considerations we did not radio-tag fish in all size groups. We tagged only three fish less than 400 mm, the smallest being 360 mm. The majority of fish tagged (57%) were between 400 and 500 mm in length (Figure 3). Thus, we did not tag representative fish for a large segment of the run. Tag weights (expressed as a percent of fish body weight) averaged 1.06% (Appendix B).

Initial behavior of tagged fish varied considerably by individual. Most fish moved upstream immediately after surgery. Radio-tagged fish moved an average of 359 m (n = 24) within 24 h of release. This movement ranged from 50 m downstream to 1,200 m upstream for individual fish.

Not all fish moved upstream above the release site. One was harvested by an angler within 24 h of release. We tagged another upstream migrant to replace the lost fish. Another fish dropped over the hatchery diversion dam 5 d after release (May 27) and moved downstream 1,200 m. The fish moved downstream 4,000 m to the mouth of Rapid River by July 24. High temperatures in the Little Salmon River may have prevented further downstream movement. We lost contact with this fish in mid-August.

All other radio-tagged fish moved substantial distances upstream. The average fish moved 22 km upstream from our release point during the duration of the spawning run (range = 4.8-29.3 km). For most fish, there was an initial period of rapid movement with many fish slowing and staging in the vicinity of the West Fork Rapid River (7 km upstream) within 2 weeks of tagging. This period was followed by another rapid increase in movement for many individuals. By June 24, the majority (70%) had moved past the West Fork Rapid River and were distributed fairly evenly between West Fork Rapid River and Fry Pan Creek (Figure 4). The uppermost two fish traveled 20 km by June 24 or about 1 km/d. The area around the West Fork Rapid River appeared to be a major staging area.

We observed a pulse of downstream movement in mid-summer (June 24 to July 27) ranging from 228-9,640 m. The likelihood of this behavior occurring was related fish size. Sixty-four percent of fish less than the median size tagged (<457 mm, small) moved downstream during this period. Twenty-one percent of fish above the median size moved downstream. This difference was significant ($P < 0.025$). Five (56%) of the small fish that moved downstream did not appear later in documented spawning areas. All tagged fish above the median size eventually appeared in or near documented spawning areas.

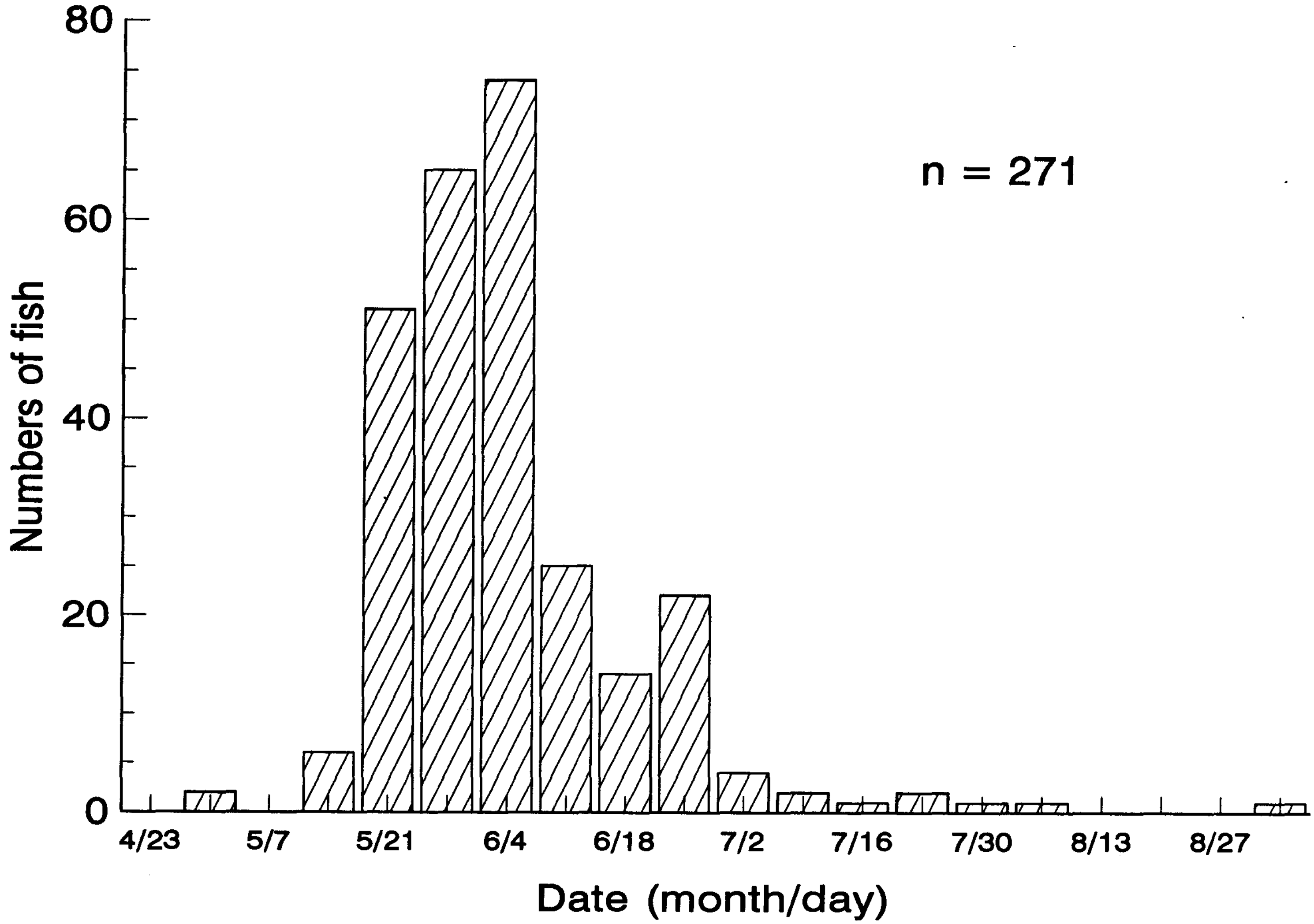

Figure 2. Weekly trap counts of bull trout moving upstream past the Rapid River weir, 1992.

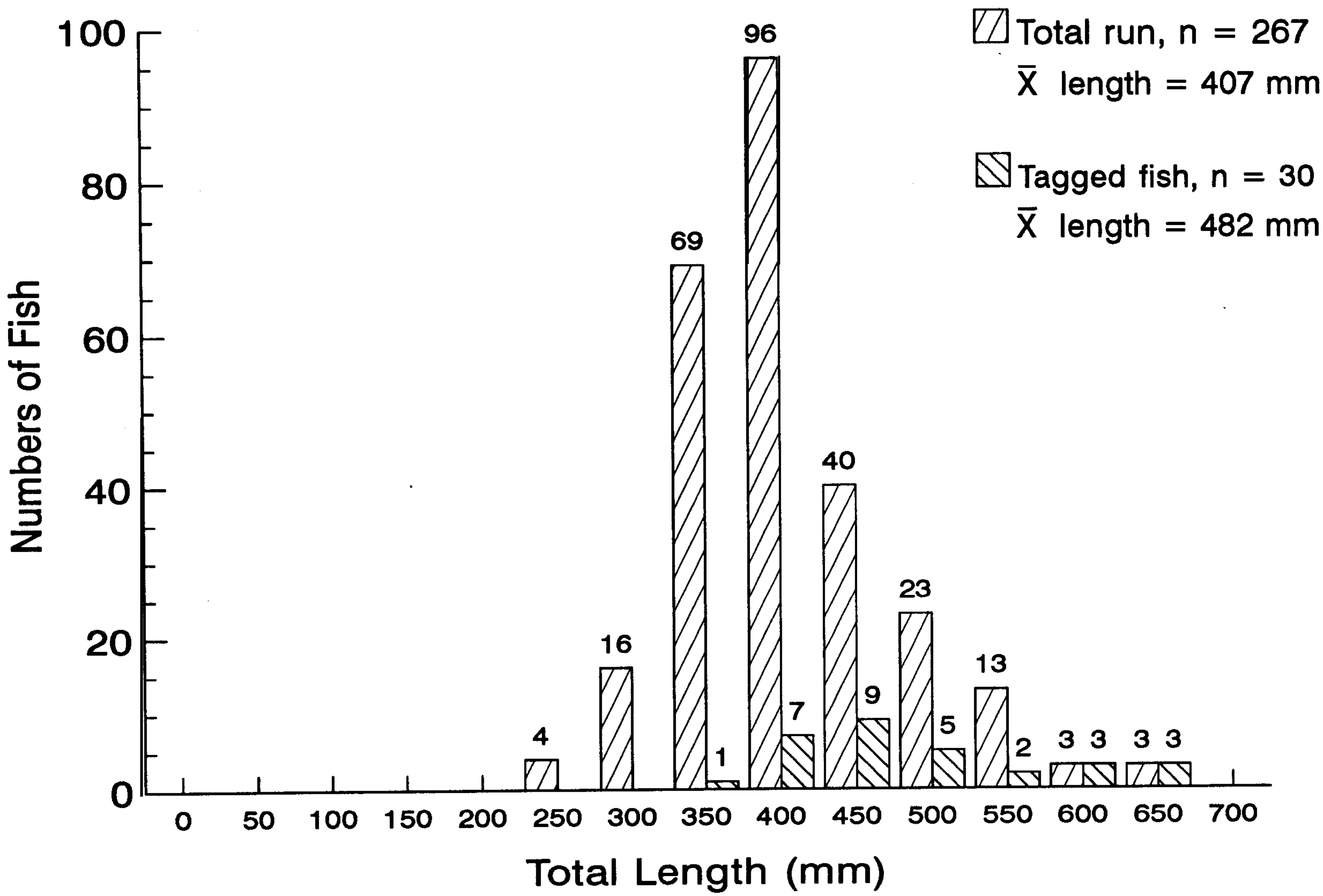

Figure 3. Length-frequency of bull trout migrants and radio-tagged fish migrating upstream past the Rapid River weir, 1992.

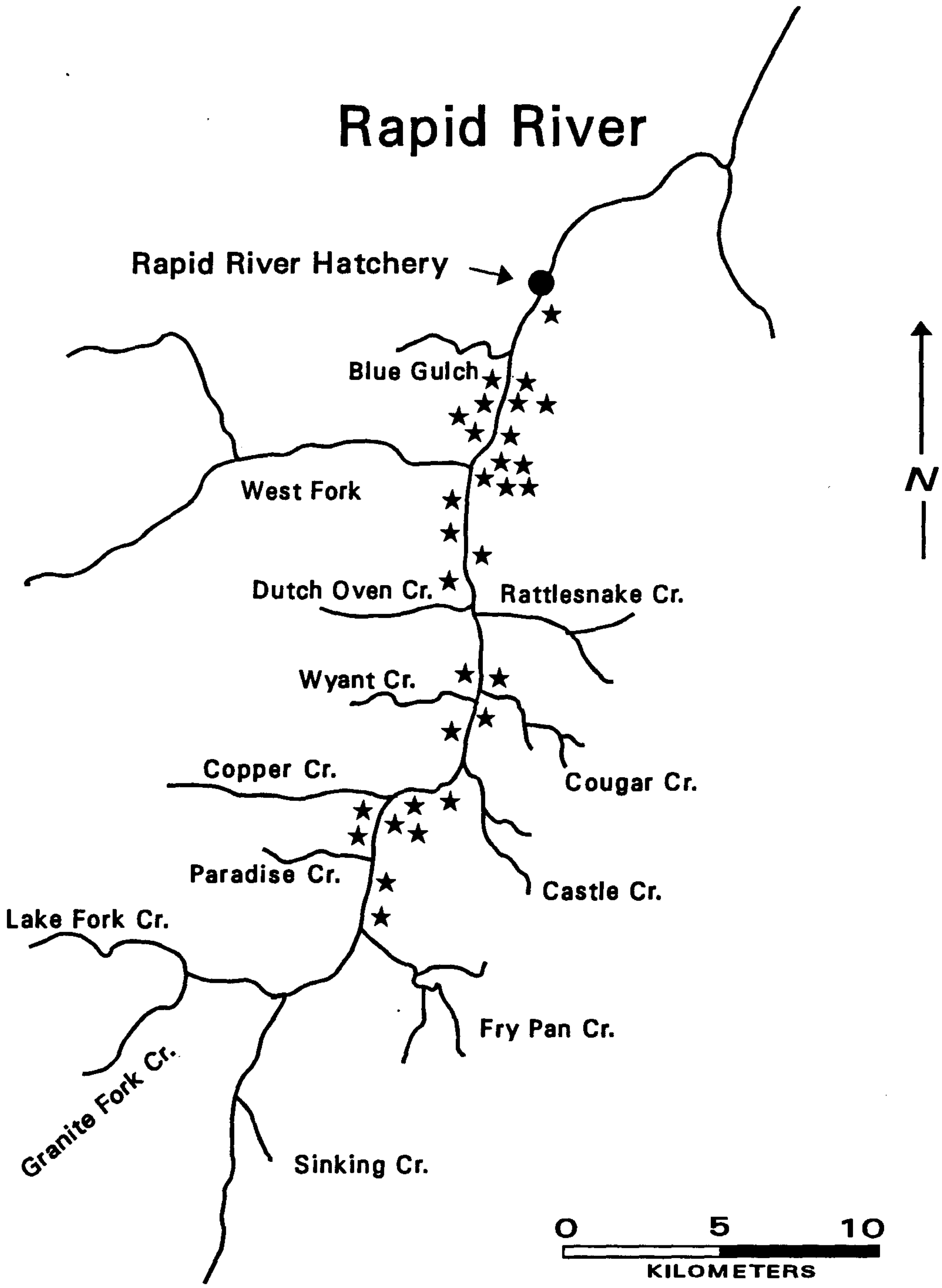

Figure 4. Location of radio-tagged bull trout in Rapid River, June 24, 1992. Stars represent individual fish, n = 30.

Bull trout spawned over a relatively short-time period. Most fish reached the general area they eventually spawned in by early August (Figure 5). We observed pairing of fish and less cryptic behavior during the August 24-28 ground survey. Pairing behavior began after average water temperatures dropped sharply from 10-6.5°C (Figure 6). When we returned the following week (September 2-4), fish were actively spawning. We observed no spawning activity on the next ground trip (September 9-11) but located several new redds. Observations of radio-tagged fish suggest actual spawning occurred over a maximum of 12 d.

We observed 24 redds and documented spawning in four segments of the uppermost 10 km in the drainage. A single redd was found approximately 1.5 km above Paradise Creek (Figure 7). An area beginning 1 km upstream of Fry Pan contained the greatest density of redds; 11 were found in a 0.7 km stream segment. The six largest fish in our tagging study all spawned in this mainstem location. Stream widths at the redd locations averaged 9.5 m. Stream gradient in this area was low for Rapid River (1.4%). Woody debris was sparse and much of the stream had an open canopy.

All remaining activity occurred in an upper tributary, the Lake Fork. The 12 redds observed in this area were scattered over 5 km including a side tributary, the Granite Fork. Habitat was much different than at the Fry Pan site with dense woody debris jams and thick canopy predominating. Stream widths at redd sites in the Lake Fork averaged 4.3 m and gradient was slightly steeper at 1.9%.

Several other segments of Rapid River seemed good candidates for spawning activity but were not used based on redd surveys. We observed no spawning activity in a 2 km stream segment near the mouth of Rattlesnake Creek despite the presence of three radio-tagged fish in the area (Figure 7). We observed no activity or bull trout in a 2 km segment above Sinking Creek despite the presence of radio-tagged fish immediately downstream, low gradient, and high quality gravel.

The data suggest heavy mortality of bull trout spawners in the drainage. Only 31% (nine) of the 29 fish that moved upstream of the release point eventually left Rapid River. Of the remaining 20 tagged fish, we recovered 15 tags. Most of the recovered tags (12) were found on the stream bottom in 5 to 45 cm of water. Three tags were found on the stream bank within 1 m of the stream. We found a maxillary bone at a single location but could find no larger body parts. We found small mammal scat at a single bank site near a recovered tag.

Five tags were not recovered. We classified these as "bank" signals because they were found along the streambank, often in rocky areas or in exposed tree roots up to 15 m from the stream.

We observed a single untagged spawning mortality in the Lake Fork 300 m below the Granite Fork confluence. No injuries were apparent for this individual, a 598 mm male.

The majority of tagged fish died during a period of downstream movement during or immediately after the spawning season. Tags from 15 fish were located

	6/10 Flight N = 30	7/7 Flight N = 29	8/11 Flight N = 29	9/8 Flight N = 20	10/9 Flight N = 18	11/5 Flight N = 7
Main Salmon River					■■■■■■ ■	■■■■■■ ■
L.Salmon R. to Hatchery	■	■	■■			
Hatchery to West Fk.	■■■■■■ ■■■■■■ ■■■■■■ ■■■■	■■■■■■ ■	■		■	
West Fk. to Castle Cr.	■■■■■■ ■	■■■■■■	■■■	■■■	■■	
Castle Cr. to Fry Pan Cr.		■■■■■■ ■■■■	■■■■■	■■	■■	
Fry Pan Cr. to Sinking Cr.		■■■■	■■■■■■ ■■■■■	■■■■■■ ■	■■■	
Sinking Cr. to Headwaters			■	■		
Lake Fk. to Granite Fk.		■	■■■	■■■	■■■	
Granite Fk. to Headwaters			■■■	■■■■■		

Figure 5. Locations of Rapid River bull trout between June and November 1992 based on radio telemetry and aerial tracking.

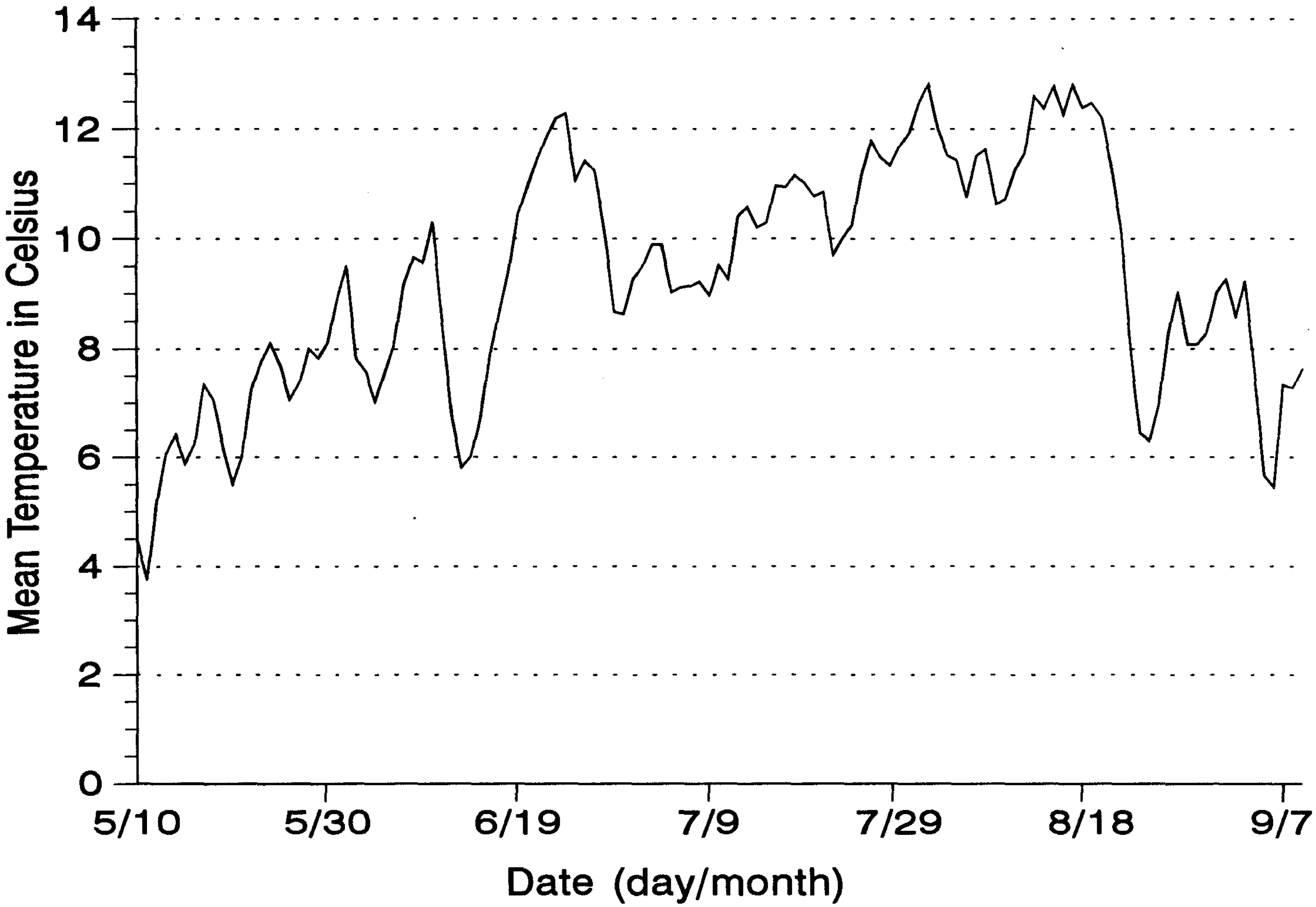

Figure 6. Mean daily water temperatures in Rapid River as measured by thermograph placed near the mouth of Fry Pan Creek, 1992.

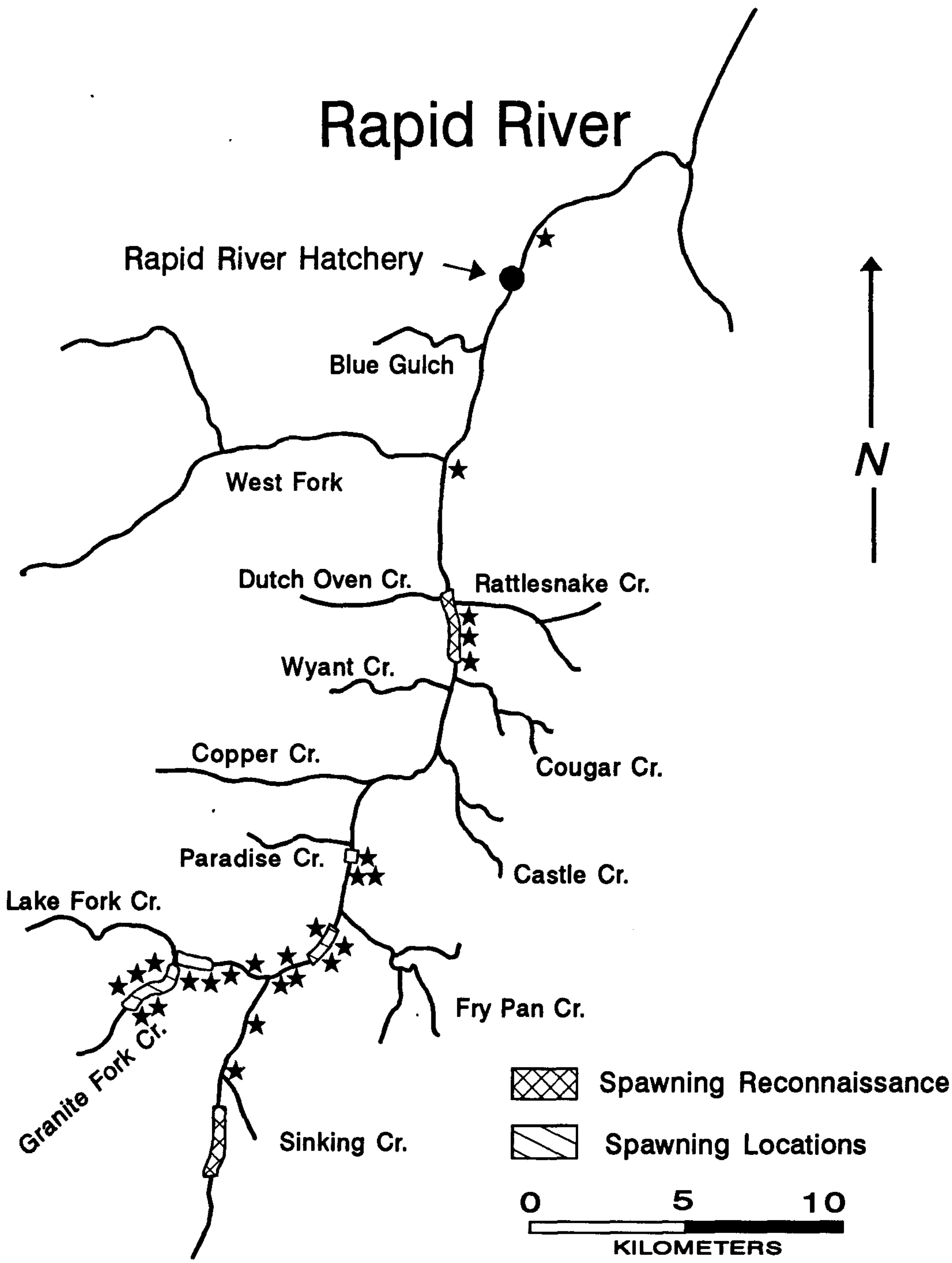

Figure 7. Location of confirmed bull trout spawning sites and additional spawning ground surveys in Rapid River, September 1992. Stars represent individual fish.

an average of 3,315 m below their farthest upstream location (range = 190-14,302 m). The remaining five fish died at the farthest upstream point they had attained, usually prior to the early September spawning period.

Post-spawning emigration was rapid for most surviving adults. Two fish moved 33 km downstream from the Granite Fork confluence to the mainstem Salmon River near Riggins between August 8 and September 15. This equates to 4.7-4.8 km/d and is a conservative estimate since we did not track daily and they may have reached Riggins before our September 15 survey date. Although all survivors did not move at such rates, 90% had migrated past the Rapid River Fish Hatchery by September 28. The last survivor was observed near the Granite Fork confluence on October 9 and had moved 20 km past the hatchery site by October 22.

The method of temperature estimation using the experimental tags was quite accurate. The correlation between measured and estimated temperatures (from tags) was highly significant ($r^2 = 0.97$, $p < 0.001$).

Summary of Typical Movements

We observed three types of bull trout migration patterns. The least common behavior in Rapid River was limited or no upstream migration followed by early (pre-August) downstream movement past the hatchery tagging site. Three relatively small fish (360, 400, and 416 mm) behaved in this manner (Figure 8). Another segment of the population (eight fish) demonstrated typical upstream migration followed by downstream movement in mid-summer. Some of these individuals moved long distances downstream before dying while others eventually returned upstream and reached documented spawning areas (Figure 9). Twenty fish (67%) eventually migrated to portions of the drainage above Paradise Creek where we documented spawning activity. Twelve of these individuals died. The remaining eight (40%) survived to reach the main Salmon River (Figure 10).

Main Salmon River

We believe a total of 10 fish from the original 30 tagged survived to reach the Little Salmon or main Salmon rivers. Eight fish were tracked out of Rapid River. A ninth fish, missing an antennae and emitting a faint signal, was last observed near the hatchery and we assume it reached the Salmon River. Another fish, mentioned previously, migrated out of Rapid River in July.

Upon exiting Rapid River, tagged fish did not use the Little Salmon River for appreciable amounts of time. Most of the tagged fish quickly distributed themselves in a 65 km segment of the Salmon River between Whitebird and Riggins. A single fish moved upstream from Riggins; the rest moved downstream (Figure 11). The longest distance moved by an individual bull trout during the entire 10-month study period was 100 km.

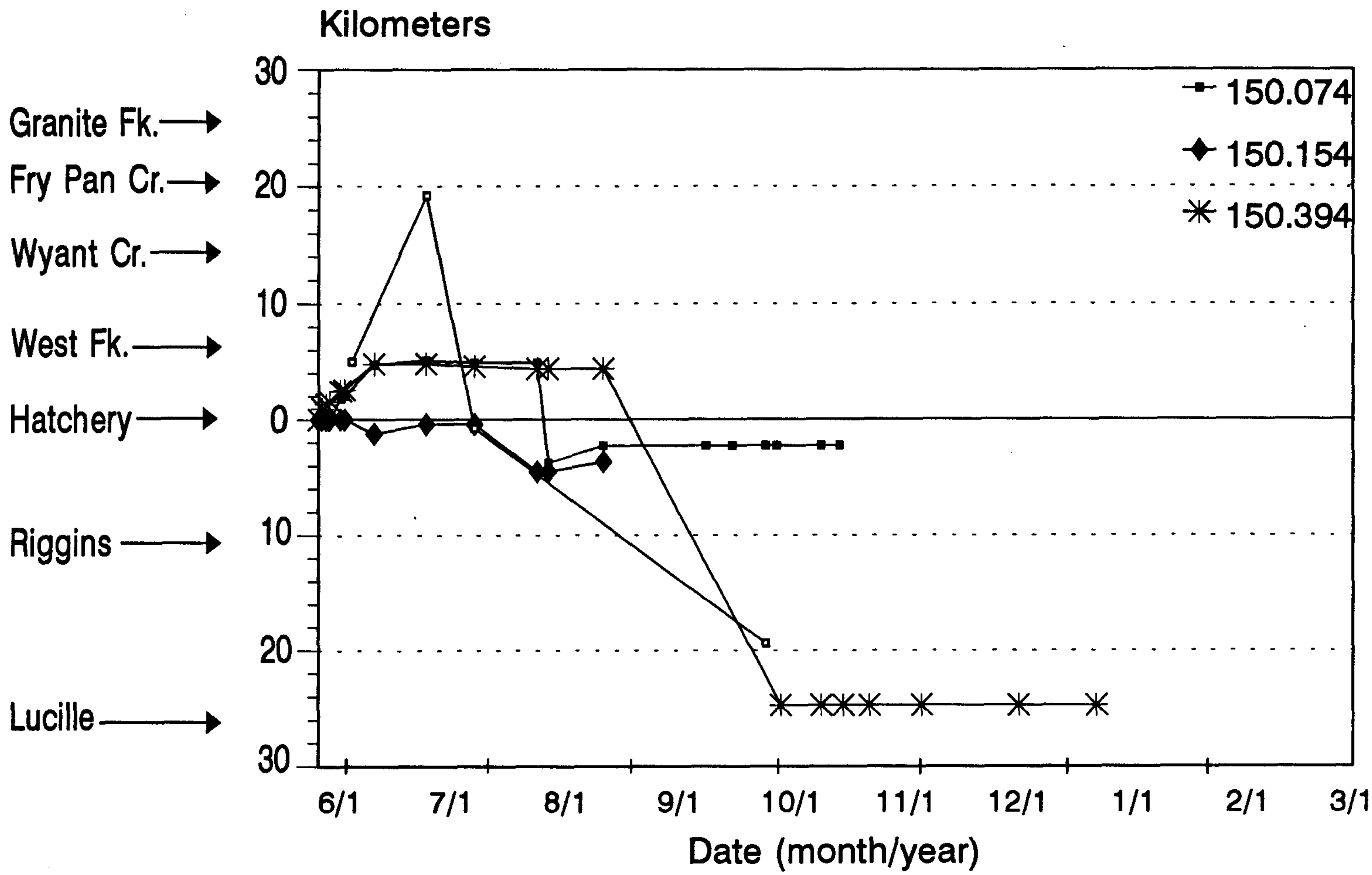

Figure 8. Migration pattern for the three Rapid River bull trout that demonstrated limited or no upstream movement based on radio telemetry.

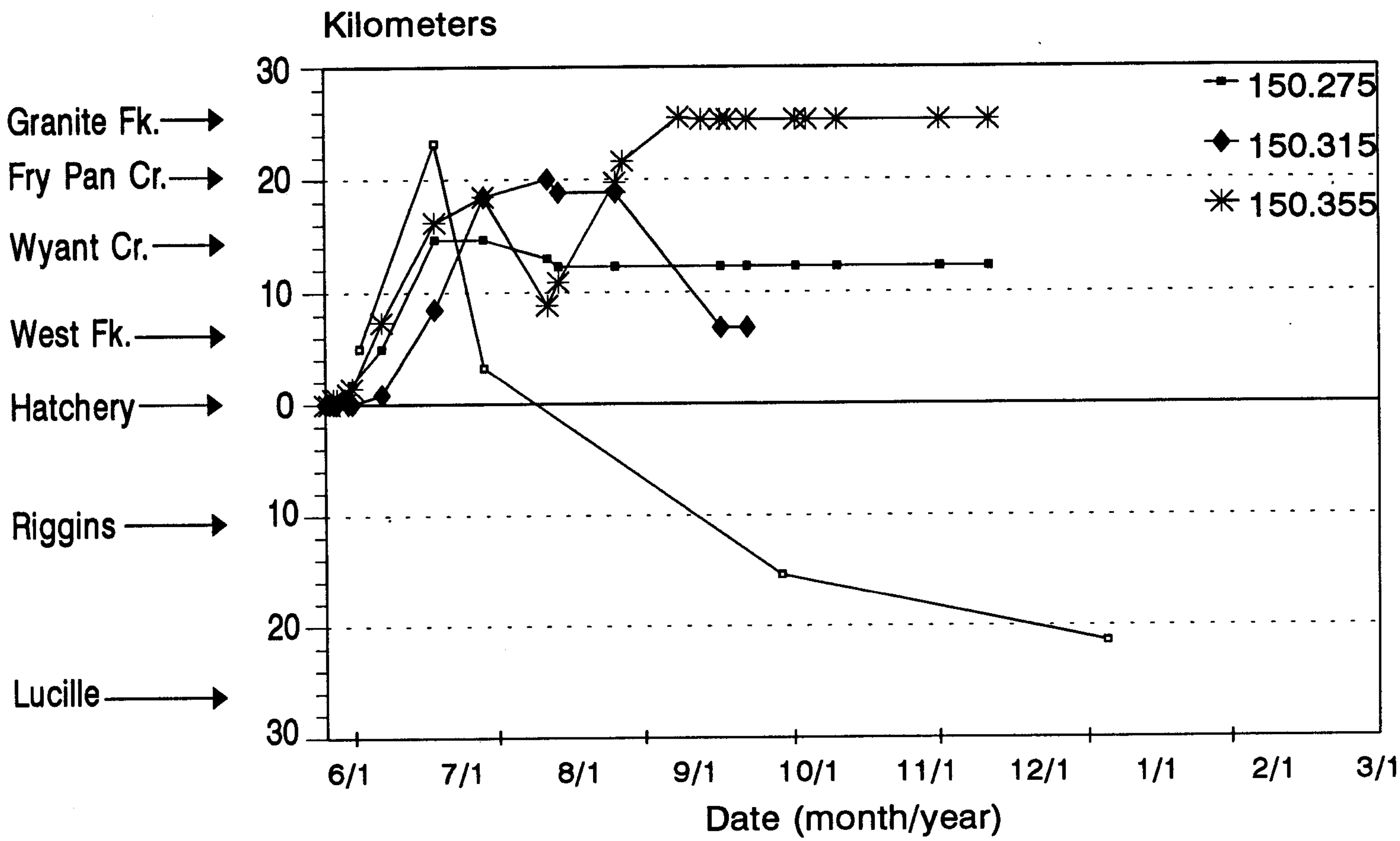

Figure 9. Typical migration pattern for Rapid River bull trout demonstrating mid-summer downstream movement based on radio telemetry.

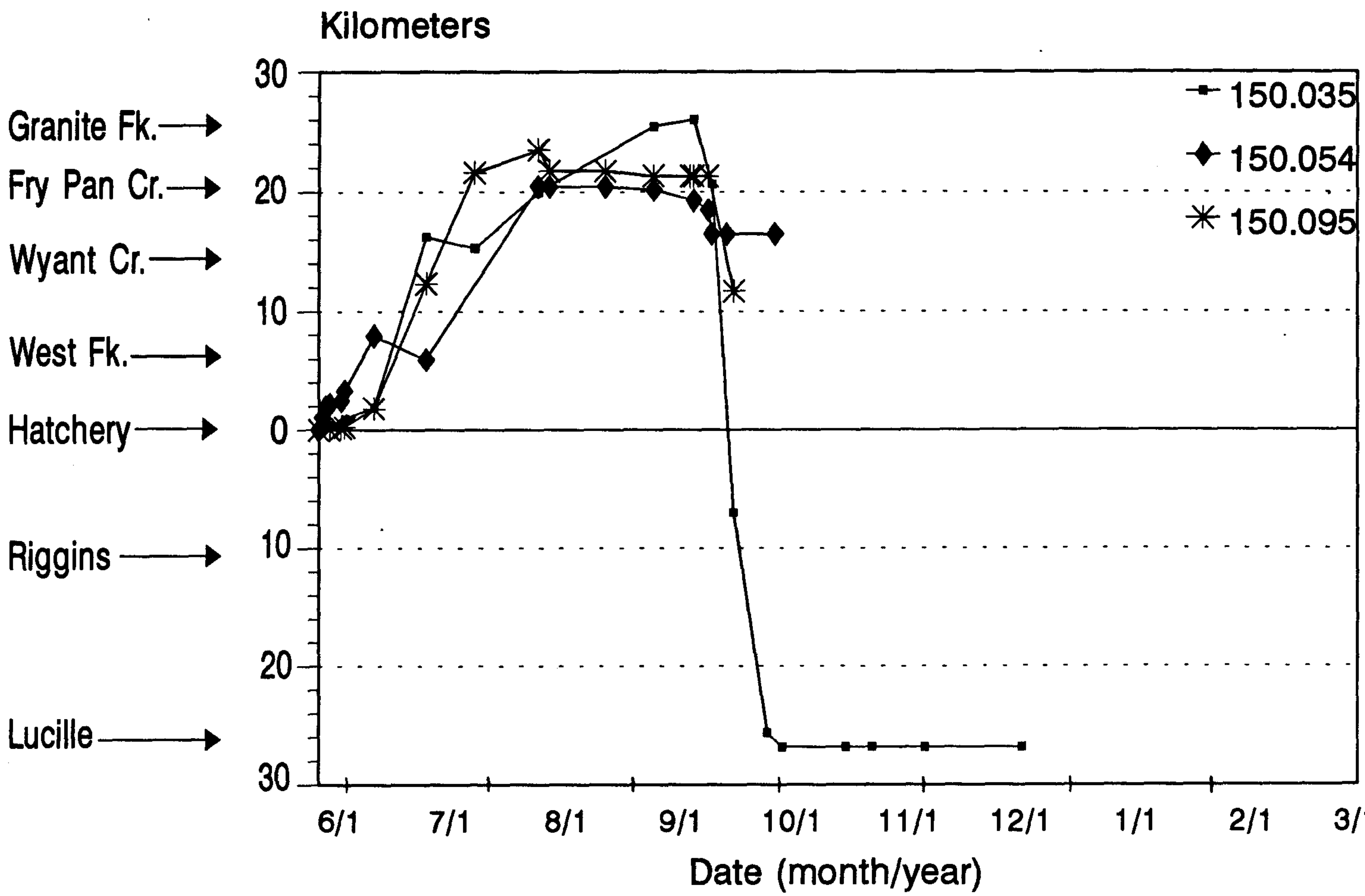

Figure 10. Typical migration patterns for radio-tagged bull trout that eventually reached documented spawning areas in the uppermost 10 stream kilometers of Rapid River.

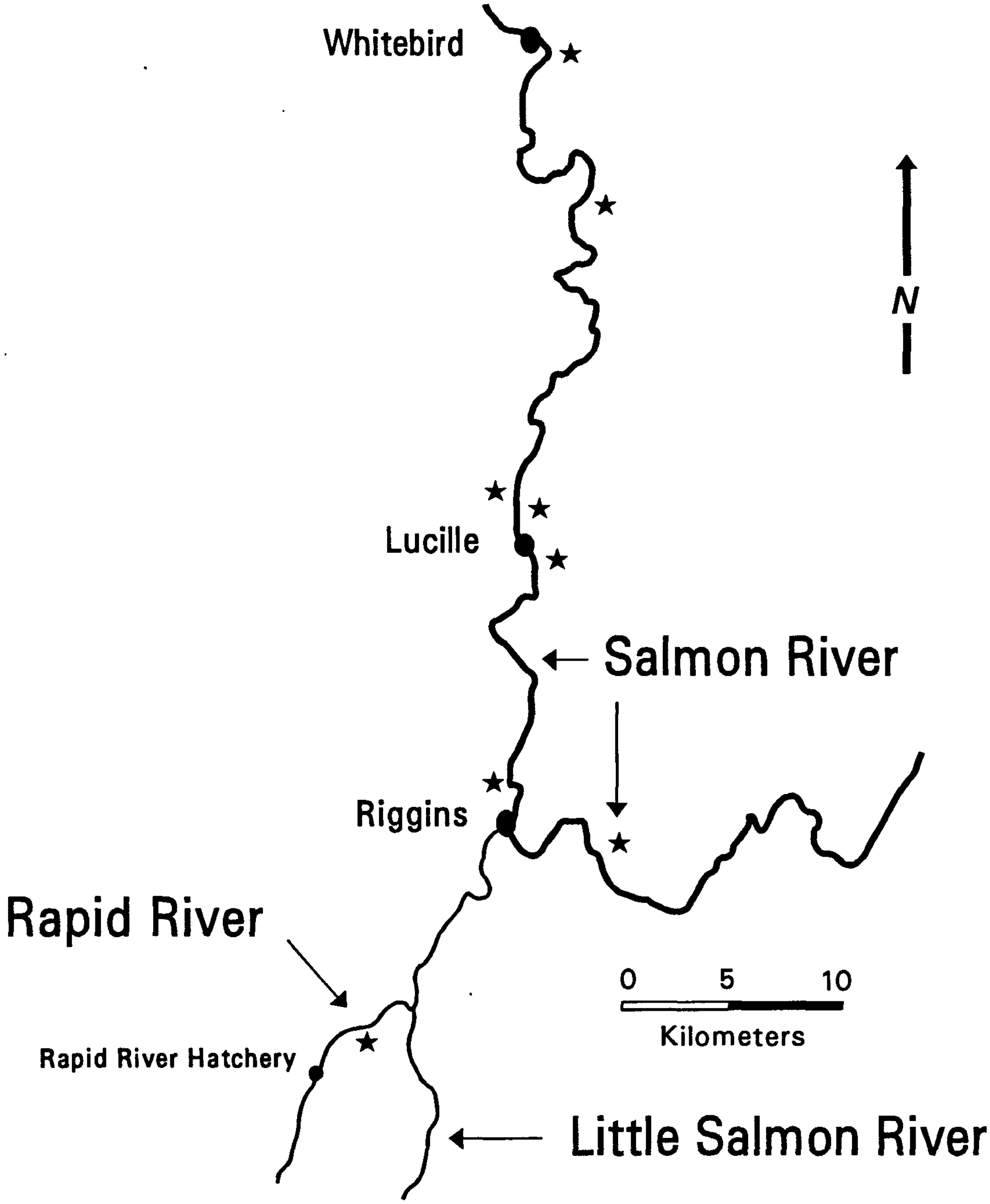

Figure 11. Location of radio-tagged bull trout in the Salmon River drainage, October 22, 1992. n = 8.

Upon entering the Salmon River, bull trout usually sought deep water habitats. We recorded a total of 33 use observations. On 28 occasions (85%), fish were located in pools or runs. Locations in shallow glides (four) and riffles (one) comprised the remainder of observations.

Overwintering bull trout showed strong site fidelity after entering the Main Salmon River. Individuals typically remained in the habitat unit they selected after cessation of downstream movement to a given point in the stream (Figure 12). We often observed movements of 50-100 m within individual units between observation days but tagged fish typically remained within a given habitat unit for the duration of the monitoring period. A single fish moved among several habitat types (450 m) between two observation dates. By the following month it had moved back to the original location however, and remained there until the cessation of our monitoring activities.

We do not know the fate of all eight fish we tracked in the main Salmon River. One fish was documented as harvested by an angler targeting steelhead trout in the fall fishery. Four others (50%) returned to Rapid River the following spring. One was harvested by Nez Perce tribal members; the remaining three moved upstream past the hatchery (Rapid River Fish Hatchery, unpublished 1993 data). The remaining three tagged fish were lost, either through signal failure, movement out of the monitoring area or to unreported sport harvest. In March, we aerially searched the entire Salmon River from its confluence with the Snake River to the mouth of the South Fork Salmon River but were unable to locate these fish. Based on strong signal strength at the time of the last tracking date, unreported angler harvest is suspected for at least one additional fish.

DISCUSSION

Our data suggest spawning in the Rapid River was limited to a small percentage of the overall drainage despite what appeared to be suitable substrate over a broader area. Several authors (Pratt 1985; Fraley 1981; Shephard et al. 1982) have reported similar observations. Temperature is thought to be a primary determinant of bull trout distribution (Goetz 1989; Rieman and McIntyre 1993). In headwater reaches, accessibility may also limit spawning. The 2 km segment we surveyed in the vicinity of Sinking Creek (Figure 7) contained the largest concentrations of spawning gravel we observed in the entire drainage, but no fish were present. Record low flows, high gradient, and extensive debris jams immediately downstream may have blocked access. Our attempts to quantitatively define suitable spawning habitat for the Rapid River stock will be reported in a subsequent report.

The macrohabitat used by bull trout stocks varies substantially. Spawning habitat in Rapid River was similar to that reported for the Flathead and Pend Orielle stocks (Pratt 1985; Fraley et al. 1981; Shepard et al. 1982). Spawning habitats in these stocks was dissimilar to those on the Lewis River, Washington, where bull trout used an extremely high gradient (18%) portion of a single tributary almost exclusively (Mike Faler, (USFS), Carson WA, unpublished data). Within the Metolious River (Mike Riehle, (USFS) unpublished data), and upper

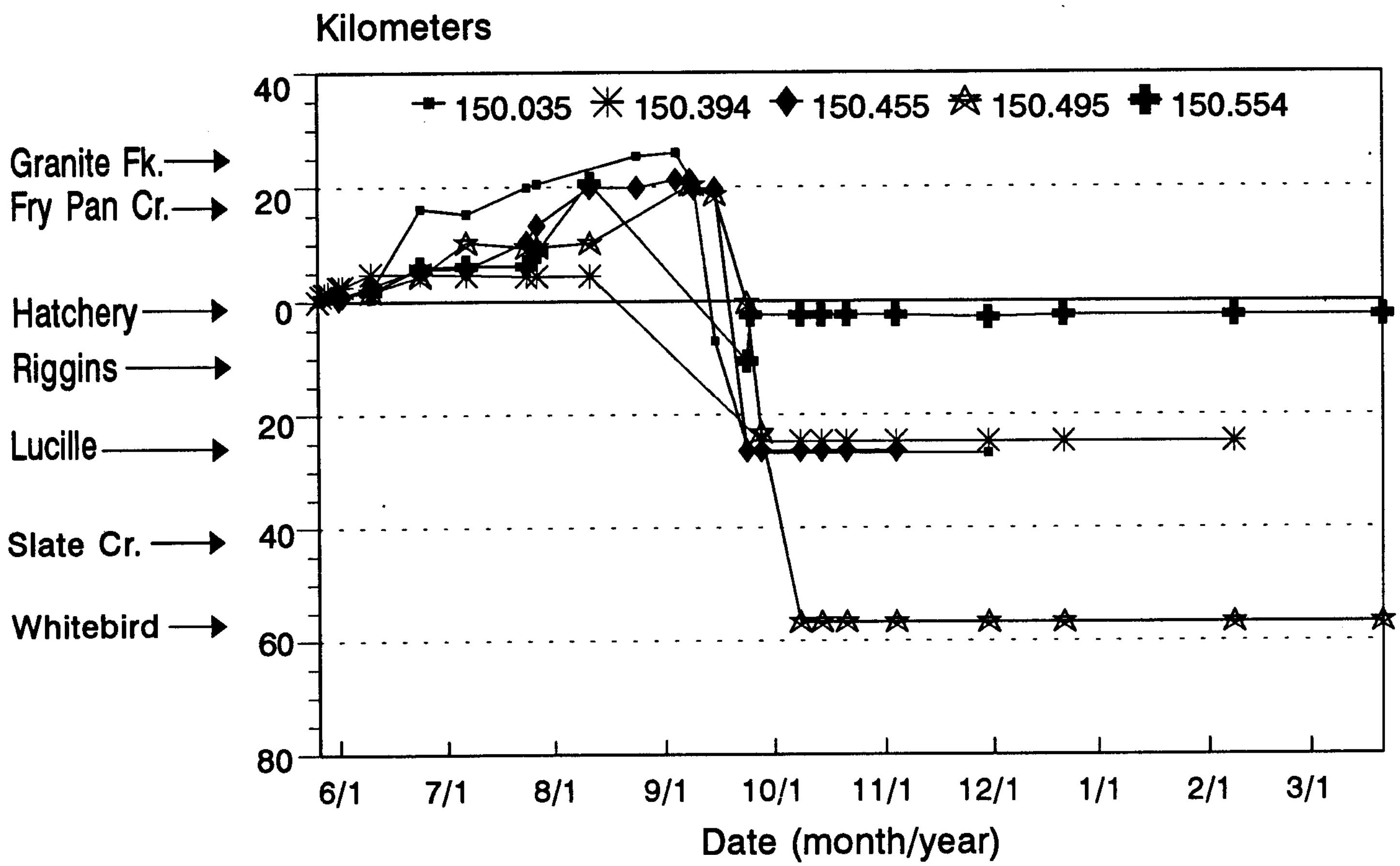

Figure 12. Typical migration pattern of radio-tagged bull trout demonstrating upstream movement to spawning areas in Rapid River and downstream movement to overwintering areas in the Salmon River.

Clearwater River drainage in Alberta (Allen 1980) low gradient spring creeks are often used as spawning tributaries.

Natural mortality for fish in Rapid River appears to be substantial. Of the 30 fish originally tagged in the spring, only 33% are known to have returned to the Little Salmon River. Faler (USFS, unpublished data) reports virtually no mortality for 20 radio-tagged bull trout in Rush Creek, a tributary to the Lewis River in Washington. Bull trout in that stream have a relatively short and unimpeded migration route. Small sample sizes limit the utility and/or comparison of estimates from both studies, however. Other estimates of spawning mortality for the species are unavailable in the literature. If confirmed with future studies, our Rapid River mortality rate (67%) will have important implications in developing management strategies for the protection and enhancement of the species. Additional work should be done on Rapid River next year to confirm the mortality results.

Our estimate of natural mortality has some important limitations. The mortality rate reported above assumes that a combination of floy and radio tags had no impacts on survival. Dunning et al. (1987) reported no mortality associated with floy tags, but McFarlane and Beamish (1990) found significant survival effects. Radio telemetry has been demonstrated to have negligible effects on mortality, growth and behavior of a variety of species (Tyus 1988; Minor 1981 as cited by Tyus). Faler (USFS unpublished data) lost only a single bull trout during a 6-month period using both radio and floy tags. It is impossible to rule out tag-related effects on our mortality estimates, however.

Initial survival of our fish was 100%; two were caught within 24 h of surgery. We were able to capture and inspect a number of fish during the year. The incisions appeared to have healed within the first month after tagging, and we observed no mortality of tagged fish within the first 7 weeks of tagging. While delayed tagging effects could have interacted with spawning stress and hastened the death of some individuals, it does not seem likely that our tagging procedures elevated the overall estimate significantly. Until additional data is obtained, however, use of both floy tags and radio tags, concurrently, should not occur unless absolutely necessary to study design.

Another possible explanation for the high mortality estimate is tag-shedding described by Summerfelt and Mosier (1984), Marty and Summerfelt (1986) and Chisholm and Hubert (1985). Tag expulsion has been shown to occur through the incision or the anus of some species (Marty and Summerfelt 1986). Most of our tags were found on the stream bottom with no signs of the carcass or body parts nearby. We cannot eliminate tag expulsion as a potential source of bias for our spawning mortality estimate. To avoid expulsion we stayed well below the recommended 2% ratio for fish/tag weight (Marty and Summerfelt 1986). Tag shedding did not occur on the Lewis River bull trout study but incisions there were made laterally, not ventrally (M. Faler, USFS, personal communication). Because of the possibility of tag-shedding and tag-related effects, our spawning mortality estimate should be considered as a maximum estimate for Rapid River until additional data is collected.

Tags found up to 15 m away from the stream suggest actual mortality whether from spawning stress or predation. We only found one untagged spawner carcass during the study but woody debris jams and overhead cover would make location of carcasses improbable.

Predation seems a likely source of mortality. We observed fish completely out of water "climbing" over logjams on several occasions. We were able to easily capture the fish by hand in these instances. Also, based on limited observations, much of downstream emigration is accomplished by the fish backing downstream. This behavior was noted on the two occasions where actively emigrating bull trout were tracked. Both fish backed through debris jams and riffles and turned around to swim downstream through deeper pools. One fish moved downstream about 750 m in 3 h in this manner. This behavior may make them highly vulnerable to predation and may explain why most of the recovered tags were found well downstream (mean distance = 3,300 m) of actual spawning sites. The abundant woody debris jams, especially in the Lake Fork, make it unlikely that post-spawning carcasses could have drifted this distance.

Results of this study do not quantify angling exploitation on the population. Anglers harvested at least five bull trout during the opening weekend including one tagged fish. A popular fishery occurs near the hatchery diversion structure because of delayed migration and bull trout releases at the site. Improved passage around the diversion structure is recommended. With the exception of this site we observed no anglers in the Rapid River drainage during the 1992 field season. A few anglers reportedly fish in upper portions of the drainage but the remoteness and lack of roaded access probably result in minimal harvest.

Results of the winter movement work indicates that bull trout from Rapid River distribute themselves over a wide (at least 65 km) segment of the Main Salmon River. With one exception, movement in our study was downstream. Areas used by overwintering bull trout from Rapid River were fished heavily by steelhead anglers and incidental harvest was documented. One angler returned a tag from the Main Salmon River during the fall steelhead fishery. Three additional tags disappeared during the steelhead season and could have been related to tag failure, movement or exploitation. Knowledge of both overwintering areas for Rapid River bull trout and heavy steelhead trout angler use near Riggins has prompted a mail survey designed to estimate bull trout harvest. Results will be available in 1993.

An exploitation study should be considered for the population using outmigrants moving past the Rapid River hatchery. Construction of a downstream weir and a floy tagging program using rewards may result in a sufficient sample to examine fishery effects on the stock. Such a weir would also enable us to examine spawning mortality for the stock and evaluate the effects of radio tagging on survival if additional work is considered.

Movement data such as that generated in this study may enable us to qualitatively assess impacts of exploitation on various tributary stocks. The Rapid River stock spreads out over at least a 65 km segment of the Salmon River. This type of information, coupled with future harvest estimates for the area, may give us a general approximation of harvest effects on tributary stocks. Assumptions would have to be made about alternate year or consecutive year spawning and the bull trout spawning contribution of other streams in the area.

Fluvial stocks of large bull trout exhibit extensive movement that makes their study difficult. Bjornn and Mallet (1964) reported fish movement of up to 325 km from original tagging sites in the Middle Fork Salmon River. The longest distance moved in the Rapid River study was 100 km including the spawning run and movement to an overwintering site near Whitebird. This extensive movement and limited numbers of adult fish limit movement studies using conventional floy or jaw tags etc. Radio telemetry will likely be the only realistic alternative to studying movement of large fluvial adults.

A number of factors in the study limit application of our results to the entire Rapid River spawning run. We under-represented small fish in the run and tagged no fish less than 360 mm even though they comprise a major portion of the run. Results from the few small fish we tagged suggest many fish less than 400 mm entering Rapid River in the spring do not ascend the river to spawn. They may be ascending Rapid River to avoid high temperatures in the main Salmon River during mid-summer. Future radio tagging efforts should include more small fish to better characterize movement and spawning status for this population segment. This would aid in assessing the reproductive potential of the Rapid River population which may not be as large as the total run indicates. Use of an otoscope during surgery to evaluate maturity status of small fish would also achieve that end.

Applicability of results is also limited by the short duration of our radio-tagging given the length of the spawning run. We tagged fish only during the peak of the run and, in effect, ignored early and late components. Barton (1992) demonstrated vastly different spawning destinations for early and late segments of a chum salmon Oncorhynchus keta stock using radio telemetry. Future tagging in Rapid River should include a wider portion of the run to ensure that our 1992 results adequately represent the entire stock.

Finally, drought may have influenced spawning site selection in 1992. Flows in the stream were at typical winter base levels by August (USFS unpublished flow data). Migration to areas such as the high quality gravel near Sinking Creek or into tributaries such as Copper Creek or Fry Pan may have been limited by these flows. Comparison of 1992 results to a normal flow year would be desirable before finalizing conclusions about spawning locations in the drainage.

The complex nature of the habitat in Rapid River hindered visual observation in many cases and we did not use mortality detecting tags (Bendock and Alexandersdottir 1992). We made visual contact on only 51% of those instances when we believed the fish to be alive despite excellent water visibility. Future studies with bull trout should consider the use of mortality-detecting tags. The tendency for bull trout to remain motionless on the substrate may limit information from this type of tag, but they should be considered, at least on an experimental basis.

Radio telemetry has been used recently in a number of studies to document movements of large, mobile salmonids (Clapp et al. 1990; Bendock and Alexandersdottir 1992; Barton 1992). The technique appears especially suitable for studying spawning behavior of fluvial bull trout because their spawning habitat is often widely dispersed in rugged, inaccessible areas. Conventional methods such as spawning ground surveys may be unproductive. For example Rohrer

(1990) spent several weeks and searched over 28 km for bull trout spawning areas in Middle Fork Boise River. tributaries. He located a single redd despite counting a number of large individuals in his summer snorkeling stations.

Radio telemetry enables biologists to quickly locate bull trout spawning and overwintering areas. This information will be useful for establishing trend monitoring areas or identifying sites for more intense study.

RECOMMENDATIONS

1. Improve fish passage at the Rapid river diversion site to minimize fish delay.

2. Determine if angler exploitation of the Rapid River bull trout stock is within acceptable levels for stock maintenance.

3. Conduct additional radio telemetry studies on Rapid River stock in a typical water year. Include small fish and a wider temporal component of the run. Evaluate tag effects on survival.

ACKNOWLEDGEMENTS

Rapid River Fish Hatchery personnel measured bull trout lengths for the untagged portion of the run, and Jason Vogel voluntarily assisted with surgery. Mike Radco and Kerry Overton provided access to their habitat database for the Rapid River drainage. Kieran Donahue assisted with much of the data collection. Bruce Rich provided expertise on telemetry and performed a portion of the surgeries. Personnel from the New Meadows Ranger District assisted with logistical support. Mike Dorris, Mccall Air Taxi, flew all telemetry flights with a sure hand.

This work was supported by Federal Aid in Sport Fish Restoration to the State of Idaho (Project No. F-73-R-15, Subproject II, Study IV) and by The United States Department of Agriculture, U.S Forest Service.

LITERATURE CITED

Allen. J.H., 1980. Life history notes on the dolly varden char (Salvelinus malma in the upper Clearwater River, Alberta, Energy and Natural Resources, Fish and Wildlife Division, Red Deer, Alberta, 59 pp.

Barton, L. 1992. Tanana River Alaska chum salmon radio telemetry study. Division of Sportfish, Alaska Dept. of Fish and Game, Fishery Manuscript 92-01, Anchorage, Alaska.

Bendock, T., and M. Alexandersdottir. 1992. Mortality and movement behavior of hooked-and-released chinook salmon in the Kenai River recreational fishery, 1989-1991. Fishery Manuscript No. 92-2. Alaska Department of Fish and Game, Anchorage, 65 pp.

Bisson, P.A., J.L. Nielsen, R.A. Palmason, and E. Grove. 1982. A System of naming habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow. Pages 62-73. In N.B. Armatrout, ed., Acquisition and Utilization of Aquatic Habitat Inventory Information. American Fisheries Society, Western Division, Bethesda, Maryland.

Bjornn, T.C., and J. Mallet. 1964. Movements of Planted and Wild Trout in an Idaho River System. Transactions of the American Fisheries Society 93: 70-76.

Chisolm, I.M., and W.A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American Fisheries Society 114: 766-767.

Clapp, D.F., R.D. Clark, and J.S. Diana. 1990. Range, activity, and habitat of large, free-Ranging brown trout in a Michigan stream. Transactions of the American Fisheries Society 119:1022-1034.

Dell, M.B. 1968. A new fish tag and rapid cartridge-fed applicator. Transactions of the American Fisheries Society 97: 57-59.

Dunning, D.J., Q.E. Ross, J.R. Waldman, and M.T. Mattson. 1987. Tag retention by, and tagging mortality of, Hudson River striped bass. North American Journal of Fisheries Management 7: 535-538.

Fraley, J., D. Read, and P. Graham. 1981. Flathead River fisheries study. Montana department of Fish, Wildlife and Parks, Kalispell.

Goetz, F. 1989. Biology of the bull trout (Salvelinus confluentusl, a literature review. USDA Forest Service, Willamette National Forest, Eugene, Oregon.

Marty, G.D., and R.C. Summerfelt. 1986. Pathways and mechanisms for expulsion of surgically implanted dummy transmitters from channel catfish. Transactions of the American Fisheries Society 115: 577-589.

McFarlane, G.A., and R.J. Beamish. 1990. Effect of an external tag on growth of sablefish (Anoplopoma fimbrial, and consequences to mortality and age at maturity. Canadian Journal of Fisheries and Aquatic Sciences 47:1551-1557.

Minor, J.D. 1981. Aquatic applications of radiotelemetry and corresponding methods of data analysis in studying the behavior of fish in their natural environment. In Long, E.F. ed., Proceedings of the Third International Conference on Wildlife Biotelemetry. University of wyoming, Laramie.

Overton, C.K., M.A. Radko, and R.L. Nelson. 1993. Fish habitat conditions: using the Northern/Intermountain Regions' inventory procedures for detecting differences on two differently managed watersheds. Gen. Tech. Rep. INT-300. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 14 p.

Pratt, K.L. 1985. Pend Oreille trout and char life history study. Idaho Department of Fish and Game in cooperation with Lake Pend Oreille Idaho Club. Boise, ID, 105 pp.

Rich, B.A. 1992. Population dynamics, food habits, movement and habitat use of northern pike in the Coeur d'Alene Lake system, Idaho. Idaho Department of Fish and Game, Completion Report, Project F-73-R-14, Boise, Idaho.

Rieman, B.R. and J.D. McIntyre. 1990. Demographic and habitat requirements for bull trout. USFS Intermountain Research Station, Work Unit 4203. Boise, ID.

Rohrer, R.L. 1990. Upper Boise River Fisheries Investigations. Job Performance Report, Idaho Department of Fish and Game, Project F-73-R-12, Boise, ID.

Rosgen, D.L. 1985. A stream classification system. North American Riparian Conference. Tucson, Arizona. April 16-18 1985.

Ross, M.J., and C.F. Kleiner. 1982. Shielded-needle technique for surgically implanting radio-frequency transmitters in fish. Progressive Fish Culturist 44(1): 41-43.

Shepard, B.B., J.J. Fraley, T.M. Weaver, and P. Graham. 1982. Flathead River fisheries study. Montana Department of Fish, Wildlife and Parks, Kalispell.

Schill, D.J. 1992. Idaho Department of Fish and Game, Job Performance Report, Job 3 Bull Trout Investigations, Project F-73-R-13 Boise, Idaho.

Summerfelt, R.C., and D. Mosier. 1984. Transintestinal expulsion of surgically implanted dummy transmitters by channel catfish. Transactions of the American Fisheries Society 113: 760-766.

Tyus, H.M. 1988. Long-term retention of implanted transmitters in colorado squawfish and razorback sucker. North American Journal of Fisheries Management 8: 264-267.

Zar, J.H. 1974. Biostatistical Analysis. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

APPENDICES

Appendix A. Summary of telemetry observation dates for the Rapid River telemetry study.

Date	Foot	Air	Vehicle	Survey Location
5/27/92		x		Hatchery Thorn Gulch
5/28/92		x		Hatchery Thorn Gulch
5/29/92		x		Hatchery above Thorn Gulch
6/1/92		x		Hatchery above Thorn Gulch
6/2/92		x		Hatchery to above Thorn Gulch
6/10/92		x		Hatchery to Rattlesnake Cr.
6/10/92		x		Rapid River
6/24-6/25/92		x		Hatchery Paradise Cr.
7/7/92		x		Rapid River
7/24/92		x		Rapid River
7/27-7-31/92		x		Headwaters to Hatchery
8/11/92		x		Rapid River
8/11-8/13/92		x		Headwaters to Fry Pan Cr.
8/24-8/28/92		x		Headwaters to Paradise Cr.
9/2-9/4/92		x		Headwaters to Paradise Cr.
9/8/92		x		Rapid River
9/9-9/11/92		x		Headwaters to Paradise Cr.
9/15/92		x		Rapid River & Little Salmon
9/15-9/18/92		x		Paradise Creek to Hatchery
9/24/92		x		Main Salmon to Whitebird
9/28/92		x		Rapid River & Main Salmon
9/28-10/1/92		x		Headwaters to Fry Pan Cr.
10/9/92		x		Rapid River & Main Salmon
10/15/92		x		Main Salmon to Whitebird
10/22/92		x		Rapid River & Main Salmon
10/22/92		x		Main Salmon to Whitebird
11/5/92		x		Rapid River & Main Salmon
11/17-11/19/92		x		Headwaters to Hatchery
12/1/92		x		Main Salmon to Whitebird
12/22/92		x		Main Salmon to Whitebird

Appendix B. Sizes of bull trout and radio tags used in the Rapid River telemetry study.

Date tagged	Radio tag number	Fish length (mm)	Fish weight (g)	Radio Tag weight (g)	Tag % of body weight
5/26/92	150.234	490	1,300	11	0.85
5/26/92	150.315	452	1,150	6	0.52
5/26/92	150.015	423	760	10	1.31
5/26/92	150.335	410	740	6	0.81
5/26/92	150.355	400	665	6	0.90
5/26/92	150.414	622	2,206	20	0.91
5/26/92	150.174	432	850	10	1.18
5/26/.92	150.154	400	750	10	1.33
5/26/92	150.054	454	1,000	10	1.00
5/26/92	150.595	569	2,075	20	0.96
5/27/92	150.074	416	735	10	1.36
5/27/92	150.195	391	685	10	1.46
5/27/92	150.275	435	875	11	1.26
5/27/92	150.135	454	950	10	1.05
5/27/92	150.394	360	475	6	1.26
5/27/92	150.214	434	900	11	1.22
5/27/92	150.254	460	950	11	1.16
5/27/92	150.115	462	925	10	1.08
5/27/92	150.375	410	750	6	0.80
5/27/92	150.035	452	950	10	1.05
5/27/92	150.515	551	1,610	20	1.24
5/27/92	150.434	513	1,475	20	1.35
5/28/92	150.095	495	1,125	10	0.89
5/28/92	150.294	475	1,120	11	0.98
5/29/92	150.455	630	2,924	20	0.68
6/01/92	150.554	520	1,540	20	1.30
6/01/92	150.575	542	1,575	20	1.27
6/01/92	150.474	593	2,165	20	0.92
6/01/92	150.495	595	2,200	20	0.91
6/01/92	150.534	627	2,781	20	0.72
				Mean % of body wt. =	1.06

J3AB

Submitted by:

Dan Schill
Principal Fisheries Research
Biologist, IDFG

Russ Thurow
Research Scientist, USFS

Paul Kline
Senior Fisheries Technician, IDFG

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Steven M. Huffaker

Steven M. Huffaker, Chief
Bureau of Fisheries

Virgil K. Moore

Virgil K. Moore
Fisheries Research Manager